# INERTIAL SPACE

The expression **inertial space** refers to the background reference that is provided by the phenomenon of inertia.

Inertia is opposition to change of velocity, that is: change of velocity with respect to the background, the background that all physical processes are embedded in. Accelerometers measure how hard an object is accelerating with respect to inertial space. More precise: accelerometers measure the magnitude of the change of velocity with respect to inertial space.

The Inertial guidance systems that are used in navigation and in guidance of missiles work by detecting acceleration and rotation with respect to inertial space.

## Derivatives with respect to time

Position, velocity and acceleration form a natural sequence. Position can be seen as the zeroth time derivative of position, velocity is the first time derivative of position, and acceleration is the second time derivative of position.

The scientific understanding of space and time is that there does not exist such a thing as measuring an object's position with respect to inertial space, and no such thing exists as measuring an object's velocity with respect to inertial space. It is the third in the sequence, acceleration with respect to the background, that is the first to be physically manifest.

## Gyroscopes

A spinning gyroscope, when suspended in such a way that no torque acts on the gyroscope wheel, will remain pointing in the same direction with respect to inertial space. The spinning gyroscope is *locked* onto the direction of inertial space that the gyroscope happened to be directed in when it was spun up. Two gyroscopes that start out pointing in the same direction will remain aligned with respect to each other. Since both gyroscopes are locked onto the same inertial space, it is impossible for two spinning gyroscopes to drift with respect to each other.

## Astronomy

In 1899 the astronomer Karl Schwarzschild pointed out an observation about double stars. The motion of two stars orbiting each other is planar, the two orbits of the stars of the system lie in a plane. In the case of sufficiently near double star systems, it can be seen from Earth whether the perihelion of the orbits of the two stars remains pointing in the same direction with respect to the solar system. Schwarzschild pointed out that that was invariably seen: the direction of the angular momentum of all observed double star systems remains fixed with respect to the direction of the angular momentum of the Solar system. The logical inference is that just like gyroscopes, the angular momentum of all celestial bodies is angular momentum with respect to a universal inertial space. [1]

## Applications in navigation

Inertial guidance systems detect acceleration with respect to inertial space, and with those data it is possible to calculate the current velocity and position with respect to the velocity and position at the moment the acceleratometers started registering data.

For detecting rotation, gyroscopes and fiber optic ring interferometers are used. The operating principle of ring interferometers is called the Sagnac effect.

A gyrocompass, employed for navigation of seagoing vessels, finds the geometric north. It does so, not by sensing the Earth's magnetic field, but by using inertial space as its reference. The outer casing of the gyrocompass device is held in such a way that it remains aligned with the local plumb line. When the gyroscope wheel inside the gyrocompass device is spun up, the way the gyroscope wheel is suspended causes the gyroscope wheel to gradually align its spinning axis with the Earth's axis. Alignment with the Earth's axis is the only direction for which the gyroscope's spinning axis can be stationary with respect to the Earth and not be required to change direction with respect to inertial space. After being spun up, a gyrocompass can reach the direction of alignment with the Earth's axis in as little as a quarter of an hour.

Source : http://www.cleonis.nl/physics/phys256/inertial_space.php